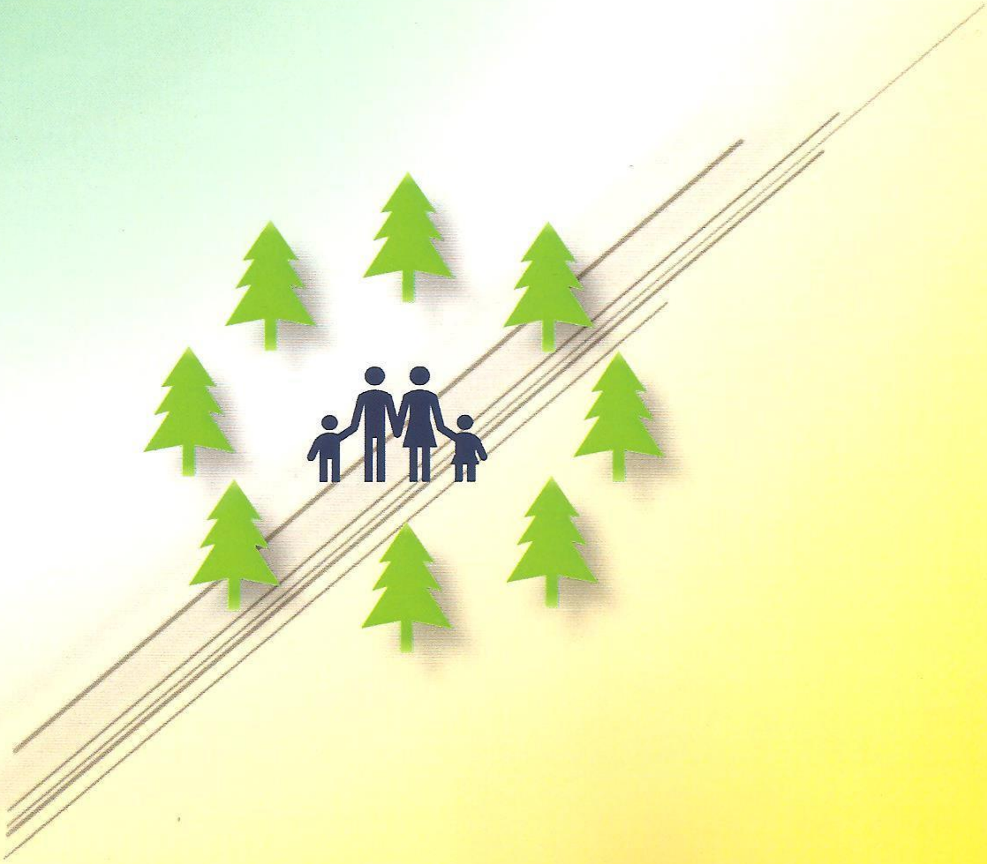
CONSTRUCTING A GREEN CIRCULAR SOCIETY



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Foreword

Editors

This book focuses on the comprehensive economic model *Circular Economy* to take the present world more sustainable green society for the next generation. Because, for the shortcomings of global economy for centuries, the current society is passing through a mediocre unrest. Poverty, inequality, opacity, drought, floods, politics and diplomacy with the reality that barriers to the formation of environmentally friendly society, fighting, violence, unrestrained people, etc. are unacceptable, and unexpected words are hurting our daily living environment directly and indirectly. The sustainable society in the sense of social justice is now questioned. This means that our targeted sustainable development has been challenged by the global challenges (climate crisis, raw material scarcity crisis, toxicity crisis, energy crisis, etc.). In this book, it can be seen in the context of how the global challenges can be tackled through timely or timely steps. Here is a timely or timely move to say the new economic model *Circular Economy*. Because the dead address addressed to the circular economy society problem in creating a sustainable green society system, with the eye which is seen by the rest of the mankind.

This book also maps circular economy's broader benefits. Our preconceived idea is that, 200 years from now, the world-wide structural benefits of this circular economy will be sung by the great people like those who have made outstanding contributions to this book today and are working day and night to see the 'Sustainable Green Society'.

Moreover, the book *constructing a green circulary society* will convey novel ideas and inspiration, benefitting policy makers, researchers, student and companies alike. It consists of nine chapters, each approaching the topic green circular society from a different perspective. The results of this book are an outcome of work done by diverse set of tallented both young and old scientists ranging from Bangladesh, Belgium, Finland, Germany, Malaysia, Mexico, the Netherlands, Sweden and Turkey. We apologies in advance for any unforeseen shortcomings.

We would like to thank the authors for their contribution and the reviewers for their constructive feedback. Our thanks also go to the following for their invaluable help/inspiration during the preparation of this book: Jahanara Ferdous Suborna, Mesbaul Islam Anindo, Nasrullah Mohammed, Hamdy Mohammed, Abdul Mannan Pappu, Voitto Kotiaho. A special word of thanks to *Children's Dream* to support for the printing of the book. We would also like to extend a particular warm thanks to Faculty of Social Sciences, University of Helsinki, Finland.

Helsinki, Finland, November 2017

Chapter 3

TRANSITIONING FROM A LINEAR ECONOMY TOWARDS A CIRCULAR ECONOMY: THE CASE OF THE APPAREL INDUSTRY

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Abstract
This chapter describes and illustrates potential benefits and challenges of a transition from the traditional, linear, organization of economic processes towards an organization of such processes based on circularity. A view is elaborated based on notions and theoretical concepts that apply to the idea of a circular economy, followed by an exploration of the main challenges and obstacles for a significant shift towards circularity. An illustrative case of a substantial shift towards circularity in the apparel industry is presented. The chapter ends with an agenda for further research and policy making.

Keywords: circular economy; transition process; apparel industry

1. Introduction
In the past decade, the debate regarding the need to change the dominant traditional linear way of working in basic economic processes towards a more circular organization of these processes has been intensifying. The need for a transition towards what is referred to as 'a circular economy' has been advocated by many researchers and policy makers (e.g., Ellen, 2013; Van Buren et al., 2016), and new business models have been proposed (e.g., Jonker, 2011; Lewandowski, 2016). Furthermore, innovative solutions have already been implemented in various domains (e.g., Jonker, 2013), and supportive policy agendas have been launched (e.g., European Commission 2015).

Although these events might suggest an accelerating large-scale transition, the required structural change of economic and business practices appears to be extremely challenging. Changing the system is a matter of many small steps and endurance. The promising theoretical perspectives on the benefits of a circular economy with respect to economic, social and environmental dimensions of society, and hence a more sustainable development, often appear insufficient to overcome various technical, institutional, economic and social barriers to a large-scale transition.

The present chapter aims to describe and illustrate potential benefits and challenges of a transition from the traditional, linear organization of economic processes towards a circular organization of such processes. Since this subject is so encompassing and complex, we must limit ourselves. We will, in the next section, first elaborate our view on basic concepts associated with a circular economy. Next, the main challenges and obstacles to a significant shift towards circularity will be explored. In the fourth section, an illustrative case of attempts to shift apparel industry towards circularity is analysed. Section five draws the main conclusions, followed in section six by raising some points of discussion.

2. Demarcation of linear and circular economy

Circular economy is a term that has been coined as opposed to the concept of a linear economy, a generally used label for traditional economic business processes. These labels require further explanation to understand the essential differences between the two, and to identify the challenges anyone desiring a transition may encounter.

The dominant practice of business processes in production industries has long been based on the sequence of (a) producing and procuring raw materials essential for production, (b) using these raw materials for producing the goods, (c) branding, marketing and selling the product, (d) use and maintenance, and (e) disposal of the product as waste. Generally, in the first three steps, economic value is added to the end products. The market price is an expression of the buyers' willingness to pay for owning and using the product. In step (e), basically, the economic value of waste is considered negative (waste treatment costs money), or at its best considered (near to) zero. In its simplest form, in this linear view on the production –consumption process, the value chain is considered a pipeline, where raw materials enter and waste results at the end. With a growing world population and increasing welfare, and with a growing dependency on energy use per capita, the amount of raw materials produced and consumed (including fossil resources) has grown exponentially over de past decades. Increasingly, less-accessible locations for mining have to be explored, causing significant negative impact on the social and natural environment. Geopolitical strategies harden and global tensions grow, since businesses and nations aim to secure access to increasingly scarce resources. The other side of the coin concerns the enormous amount of waste that societies have to deal with.

These system dynamics and effects have first been extensively analysed and described in the notorious publication '*The Limits to Growth*' by the Club of Rome (Meadows et al., 1972), which is to be read as a major wake-up call. An iconic follow-up was the so-called Brundtland report (*Our Common Future*) by the World Commission on Environment and Development (1987), addressing the global problems of non-sustainable production and consumption patterns and their global social and environmental consequences. This report stressed the need for a major shift towards more sustainable development, balancing people, planet and profit. In the decades following, the Brundtland report has increasingly framed major debates on socio-economic developments. Notions such as 'cradle-to-cradle', 'responsible entrepreneurship', 'closed loop', 'multiple value creation' and recently 'blue economy' (Pauli, 2017), were coined as further elaborations of Brundtland's call for sustainability. This process has, mainly since the beginning of this century, been accelerated by a wealth of studies on global warming associated with the use of fossil energy.

In response to these developments, the concept of a circular economy has been advocated as a sustainable alternative to the linear 'take, make, dispose' economy. The main principle embraced in circularity is to significantly reduce the production and consumption of raw materials in combination with a strategy to recover and reuse resources from waste. "A circular economy aims for the creation of economic value (the economic value of materials or products increases), the creation of social value (minimization of social value destruction throughout the entire system, such as the prevention on unhealthy working conditions in the extraction of raw materials and reuse) as well as value creation in terms of the environment (resilience of natural resources)" (Van Buren et al., 2016, p. 3). Cramer (2014) describes nine gradations / options for circularity, often referred to as the nine R's:

1. Refuse: preventing the use of raw materials;
2. Reduce: reducing the use of raw materials;
3. Reuse: product reuse (second-hand, sharing of products);
4. Repair: maintenance and repair;
5. Refurbish: refurbishing a product;
6. Remanufacture: creating new products from (parts of) old products;
7. Repurpose: product reuse for a different purpose;
8. Recycle: processing and reuse of materials;
9. Recover energy: incineration of residual flows.

In today's societal practices, important steps have been taken to introduce processes of reuse, repair and recycling, adding significant feedback loops to the linear production-consumption model. These loops are often approached as separate optimization steps. The concept of circularity however, goes substantially further. First, it focuses on designing products in such a way that they can be easily repaired, disassembled for renewed use of components, or enable an easy recuperation of raw materials. And secondly, related to the first issue, it focuses on splitting up product ownership and product use (e.g., Tukker, 2004), from both in the hands of the buyer - in the traditional system - to a system of permanent producer ownership of the product, while usage is provided as a service to the market. In this way, crucial materials remain in the hands of the producer. The major characteristics of the three production-consumption models discussed in this section are summarized in Figure 1.

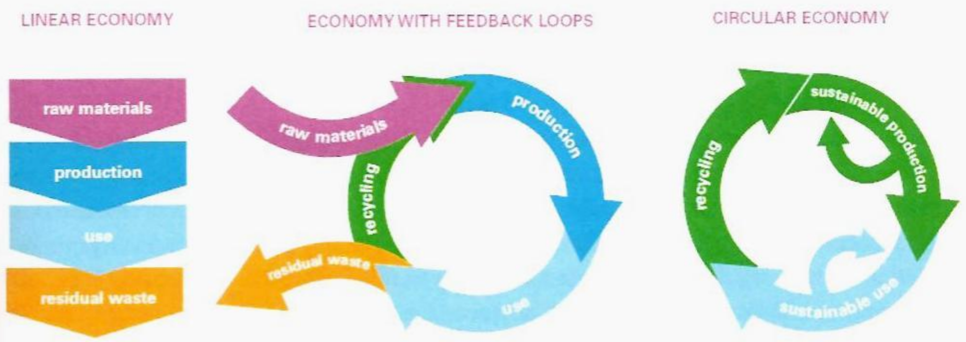

Figure 1 Characterizing linear economy, economy with feedback loops, and circular economy (RLi, 2015)

Van Buren et al. (2016) summarize the potential, and in some cases already proven, advantages of the circular economy approach in terms of three major categories. The first type of advantage is that the production processes in this setup require significantly less newly produced or mined raw materials. Consequently, these processes become less sensitive to the growing scarcity of many raw materials and suffer less from uncertainty due to the instable and strategic geopolitics of supplying countries, aimed at gaining more influence on consuming countries. This tends to outweigh the increase in uncertainty related to adequately organizing the reverse supply chain process.

Secondly, the circular economy has the potential to generate innovations and new employment opportunities in the so called eco-industry, based on the development and application of eco-technology, as well as the potential to geographically shift back outsourced activities to national economies, in processes labelled as ‘local mining’, ‘near sourcing’ or ‘reshoring’. In the past decade, the eco-industry more than doubled in size, in Europe.

The third advantage evidently concerns the reduction of environmental damage due to less extraction of raw materials, less fossil energy use and significantly smaller waste disposal problems.

Pursuing a circular economy requires major societal changes, however. The European Commission launched a Circular Economy Package in 2015 (European Commission, 2015) labelled ‘closing the loop’. The Dutch government recently published a broad policy package (Ministry of Infrastructure and Environment & Ministry of Economics, 2016) and e.g. the German government launched ProgRess, the German Resource Efficiency Programme, in 2012 (German Environment Agency, 2012), and now works on ProgRess II. Other countries are active at the national policy level as well. These policy frameworks call upon transitions in institutions, technology, societal behaviour and economic business models. They all underline the urgent need for change and describe potential benefits, but also recognize the complexity of the required transitions. The next section elaborates on these major transitions.

3. The transition challenge

Changing a linearly organized system into a circular organized system requires major systemic transitions. Such transitions imply a structural change of the system regarding various fundamental characteristics. Such transition-oriented developments generally do not occur spontaneously, although in certain cases system-external changes might stimulate systemic change, e.g., the introduction of new regulations (e.g., on food safety) or intensive societal debates (e.g., on the reduction of fossil fuel use). In many cases, however, these systemic changes must be triggered by deliberate decisions and actions from powerful stakeholders within the system. Systems' transitions are thus dependent upon the impact of purposeful change processes organized by the involved stakeholders. The change process focuses on changing the factors and processes that determine the basic structure, complexity and performance of the system. These factors involve:

- The type of system: Forward versus reverse supply chains;
- the type of innovation: Product design versus new services;
- the number of partners involved: Few versus many partners;
- the technology applied: Off-the-shelve or experimental technology;
- the relationship between actors: Contract-based or collaborative relationships, and small initiatives versus powerful players;
- the nature of the market: Local versus global markets and industries;
- the institutional conditions for the market: Regulation within one state versus international trading. And;
- the level of knowledge and understanding: Basic and/or at the surface versus in-depth and/or at the forefront understanding.

Since all the changes regarding these factors are not (nor need to be) realized with the same speed and with the same level of success, a variety of different stages in the transition of the system can be observed. These stages vary between, at one extreme, classical linearly organized production-consumption chains, and at the other extreme, a fully functional, circularly organized system. Hence, it is clear that such transition processes are complex regarding the changes in the system's structure, are dynamic regarding the changes in the system's behaviour and are uncertain regarding the changes in the system's performance. In much of the literature on such transition management processes (see e.g., Rotmans et al., 2001; De Bruijn et al., 2003; Kemp et al., 2007) it is argued, and partly empirically illustrated, that the success of such a deliberately pursued transition strategy is strongly dependent upon the degree to which the process is organized and managed. The literature emphasizes issues such as:

- Involved stakeholders should have a shared view on the basic features of the present system and develop a shared vision on strategic aims to be realized when introducing or reinforcing measures for improving circularity;

- there must be a sufficient level of agreement on the necessary conditions for a successful process, such as: the data / facts that underlie the understanding of the present system state and the expectations regarding the impact of intended interventions, the basic uncertainties herein, the willingness of the stakeholders to take certain shared and individual risks and the minimum level of support from policy makers;

- involved partners must share their views on how to deal with risks, such as: doing additional research (and also: how), choose and implement no-regret measures, committing powerful players who can act as game changer, and/or guarantee the support of policy makers;

- they need to establish an agreement on the way of collaboration (code of conduct), describing what is expected in terms of sharing information, the rules for new stakeholders entering the collaborative network as well as individual exit rules, the way of communication within the collaborative network and to the outside world, the way actions and responsibilities are monitored and valued;

- the process requires a system of monitoring and evaluation of progress: which targets must be reached and when, and what are the criteria for determining whether the development was a success or a failure? And;

- a shared view on scaling up in case of success and scaling down and possibly termination in case of stagnation or failure of the initiative, reckoning with individual interests of the participating parties.

Clearly, the more complex the system and the higher the transition ambition, the greater the dynamics will be in the transition process, and the more perturbing factors will be included. Consequently, it then becomes more difficult to organize the transition as a controlled process. Van Buren et al. (2016) mention a series of barriers for change and perturbing factors that have a significant impact on transition processes towards a circular economy. These factors have been summarized into four categories: economic, institutional, social and knowledge-related.

The category of *economic factors* is directly linked to the critical necessity for involved companies to work within an economically sound business model. A realistic and robust expectation of sufficient economic earnings, as compared to the companies' costs, is essential for commitment and involvement. Given the innovative nature of circular value systems, new business models are needed to meet the entrepreneurial expectations. The presently dominant business models too strongly focus on optimizing economic value for the individual company and insufficiently take into account value creation in multiple dimensions, and joint business with other partners in production – consumption chains. Attention for new circular business models is growing. E.g., Jonker (2013) describes a series of small scale circular business models for what he calls the 'weconomy'. Such models, to a more or lesser degree, share the following principles: (a) focus on sharing, swapping, leasing and second life, (b) focus on horizontal collaboration, creating more than merely economic value, (c) accepting transactions based on exchanging service, time, credits or local money, and (d) often focused on crowdfunding. However, as mentioned previously, these models are so far small-scale and sometimes nothing more than theoretical designs. Barriers to further developing and implementing such models in practice are, according to Van Buren et al. (2016), among others: (a) vested interests of companies and branding organizations that cause path-dependent behaviour and resistance to change, (b) uneven distribution of costs and benefits across the chain, (c) lack of investment power and powerful game changers causing wait-and-see behaviour of involved parties, (d) deficient pricing of present products and services due to limiting the pricing of products and services to production costs and the neglect of life-cycle costing, and (e) as a result, insufficient economic triggers for companies or consumers to change their behaviour.

The category of *institutional factors* encompasses a broad range of structural rules that strongly influence the market play and the nature of the dynamics in various markets. These rules can be of a legal, cultural or social nature. Hence, they can differ between states and (global) regions. Examples are European limitations to the possibilities for cross-border trading of waste, differences in taxation regimes in different states or differences in competition policies (e.g., under European legislation intensive cooperation between companies is often prohibited). Furthermore, it is generally known that the dominant concept of a liberal and open economy is under pressure and that more centrally organized economies and measures of protectionism increasingly influence global and regional economic activities. In addition, differences in cultural and social institutions between global regions triggered by ethnic, religious or geo-political motives, increasingly influence the willingness to collaborate between companies and organizations in these regions. The concept of 'level playing field' seems increasingly difficult to realize, whereas no widely-accepted set of alternative rules is available yet. The third category of *social factors* summarizes barriers and disturbing mechanisms related to the general acceptance of circular products and services. First, this is related to a lack of awareness and sense of urgency among consumers as well as producers. Transparency of chains and knowledge of the economic, social and environmental performance of these chains is generally limited, especially concerning international chains. For example, the basic notion that waste is not necessarily a product with a negative value, but could also be considered and treated as a resource for new production, is not common knowledge. Another example concerns the recognition of the strong relationship between the level of meat consumption and the production of greenhouse gasses. Secondly, values such as property and ownership are important within our societies. Splitting up ownership and use and replacing ownership by service ('what you have is only temporally yours'), requires a reframing of values. Moreover, the idea that new is best, while second-hand and recycled products and materials are basically inferior, is deeply rooted in many (Western) societies. Thirdly, much research provides evidence that consumer behaviour strongly depends upon social norms, perceptions, habits and traditions. These factors can be influenced by marketing narratives (e.g., regarding the functional quality of a new device, or the advantages of new sustainable products and services) as well as the public discourse (e.g., on environmental protection measures, or the need for a fundamental energy transition). However, consumers experience many influences from a large variety of views and interests, and this makes the direction of the summarized influences on values and believes hardly predictable.

Finally, the category of *knowledge-related factors* is described by Van Buren et al. (2016) as the barriers to reaching a higher level of professionalism. Think in this context of the systematic development and open access provision of a body of knowledge and methods that really helps to identify opportunities for improving circularity, for exploring the basic uncertainties and risks, and for elaborating collaborative arrangements between the involved stakeholders. This body of knowledge and methods is by nature multidisciplinary, but truly multidisciplinary research and the cross-disciplinary exchange of knowledge is scarce in practice as well as in science. Moreover, in-depth (scientific) research and (hands-on) practice are often viewed as two different worlds, with insufficient interaction and cross-fertilization. The consequence is that production-consumption chains in practice are not always receptive for innovations, whereas dissemination of newly generated knowledge often remains limited to the world of scientific researchers.

Above, we described the contours of a transition from a linear to a circular economy and emphasized various requirements and difficulties to arrange the complex transition processes. In the next section, these generic notions will be illustrated in the apparel industry, where several attempts are made, and initiatives taken to introduce circularity in production-consumption chains.

4. Shifting from linearity to circularity: the illustrative case of the apparel industry

a. The apparel production and consumption system

The term apparel industry is a simple label for what is in reality a more comprehensive and complex system. In fact, this production system consists of four interwoven industries, namely the 'primary fibre industry', the 'textile industry', the 'clothing industry' and the 'recovery and waste industry'. The primary fibre industry concentrates on the production of synthetic and natural fibres. The textile industry performs supply chain activities such as spinning and dyeing, and weaving, knitting and finishing respectively. The clothing industry focuses on clothing design and fabrication, marketing, distribution and retailing. The recovery and waste industry concentrate on supply chain activities such as collection and sorting of end-of-use or end-of-life apparel, recycling, retailing via re-use firms or exportation for re-use, and incineration. From a complex systems perspective, the recovery industry in terms of recycling and re-use can be referred to as a set of major feedback loops. The consumption system refers to consumption patterns or the use phase of apparel. See Figure 2 for a system view of the apparel industry.

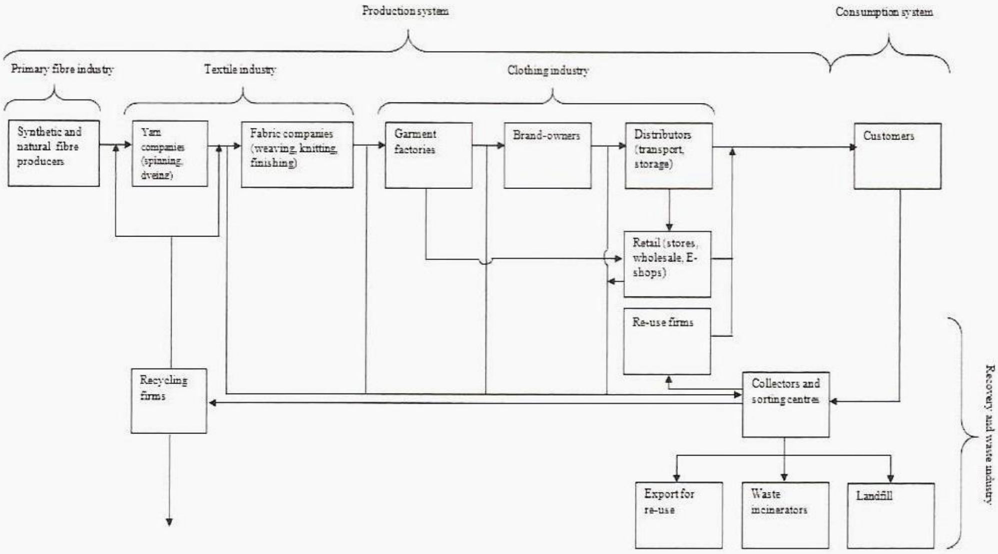

Figure 2. Current linear apparel value system with feedback loops

Based on the subdivision of the system, three global analyses will be performed hereafter. Firstly, the current situation of the system is analysed. This implies a descriptive analysis of numerical and non-numerical data about the various forward and reverse supply chain activities across multiple spatial scales, and their social, economic and/or environmental impact. We basically use the triple bottom line criteria framework, proposed by Jia et al. (2015), which consists of criteria such as toxic chemical usage, water consumption, energy usage, arable land usage and resource usage (the environmental aspect), competition, profitability and employment (the economic aspect); and child labour, wages and health (the social aspect). Secondly, (medium and long-term) external developments affecting the linear clothing system are analysed. Thirdly, value adding circular (supply chain) concepts and regulatory measures and their possible social, environmental and economic impacts are explored. To limit ourselves, for the recovery and waste industry, as well as for distribution and retail practices, we will focus on data for The Netherlands.

b. Analysing the current state

Primary fibre industry

People: The majority of fibres are produced in Asian countries. For the production of cotton, farmers use fifteen types of pesticides (Mukherjee, 2015); almost seven percent of the global amount of pesticides is used for cotton production (OrganicCotton, 2017). Research shows that the use of pesticides for cotton production causes human health problems such as chronic diseases and worker's poisonings, affect fertility and may as well have carcinogenic, allergic and neurological effects (Gardetti & Torres, 2013; Khan et al., 2015; Khan, 2010).

Planet: For the production of cotton, large surface areas and amounts of water are utilized, whereas a substantial amount of CO_2 emissions is produced, respectively 2.5 percent of the world's arable land (Jansen, 2014), 2.6 percent of global water use (Rissanen, 2008), and 0.8 percent of global CO_2 emissions (Karaosman, 2016). This makes the land used for fibre production, and in particular cotton production, vulnerable to soil degradation, depletion and the loss of biodiversity (Gardetti & Torres, 2013). For instance, in order to maintain and expand the production of cotton, entire rivers have been diverted into huge irrigation channels in Central Asia. This has led to the gradual drying-up of the Aral Lake, one of the largest inland waters in the world (OrganicCotton, 2017). In addition, it is estimated that 60 percent of irrigation water in Central and Southern Asia is lost because of cotton production (PAN UK, 2006). Then, the current average energy consumption of conventional cotton is around 130 MJ/kg, while the average energy consumption of (man-made) polyester is 175 MJ/kg (Muthu, 2014). The majority of energy consumption for fibre production is non-renewable, stemming from gas, oil and coal with high CO_2 emissions (Muthu, 2014).

Profit: In 2016, the global production of fibre is estimated at 99 million tons, of which 62.7 percent are oil-based synthetic fibres such as polyester, 24.3 percent is cotton, 6.6 percent are wood-pulp-based cellulose fibres such as viscose, 5.3 percent other natural fibres, and 1.1 percent is wool (Lenzing, 2016). Cotton production provides an income for more than 250 million people worldwide, which is around seven percent of all labour in developing countries (WWF, 2014). At the same time, the balance between supply and demand of the cotton market has become highly uncertain due to: (a) pest attacks, (b) lack of alternative fibres developed by developing countries, (c) an increasing competition from synthetic fibre 'polyester' and (d) high cotton inventories (80 percent of annual consumption) resulting in lower production and a fluctuating cotton price (OECD/FAO, 2016; Bhosale, 2016). For example, the current price (February 2017) for cotton is EURO 80 cents/lb, and experienced fluctuations in 2016 from March 59 cents/lb to 73 cents/lb in July back to 69 cents/lb in September (IndexMundi, 2017). In the period 2014-2016 world cotton inventories have reached over 80 percent of annual consumption. Prices of oil-based synthetic fibres on the other hand have structurally dropped over the last few years. The lower prices of these fibres, driven by substantially lower oil prices, have placed huge competitive pressures on world cotton markets in recent years (OECD/FAO, 2016). The market price of wood-pulp-based cellulose fibres such as viscose, on the other hand, significantly recovered in 2015, rising by an annual average of about 5 percent (Friedman, 2016).

Textile and clothing industries

People: In the textile and clothing industries, child labour is common. It has been indicated that 168 million children (almost 11 percent of the total child population) are child labourers and mainly employed by factories manufacturing textile and clothing (Moulds, 2015). Financially, this leads to low purchasing prices downstream the supply chain, yet keeps children from education and development (D'Ambrogio, 2014). Furthermore, in Asia, there is a gap between the wages clothing workers earn at the factory, and the minimum living wages necessary for a worker to meet their needs (Lu, 2016). For instance, in China the minimum living wage is €522 per month, while the factory average wage is €186. In Bangladesh, the minimum living wage is €340, while the factory average wage is €60 (Demkes, 2017). Because of this gap, poverty results in lower welfare for factory workers (Maas et al., 2016).

Planet and Profit: In 2015, the textile and clothing industries in the European Union (EU-28) generated a turnover of 169 billion €, with total investments of 4 billion €, and employed 1.7 million workers (Euratex, 2016a). Over the period 2014-2015, a turnover growth of 0.5 percent and an employment growth of 0.6 percent were observed in the textile industry (Euratex, 2016b). In the clothing industry, during that period a turnover growth of 1.5 percent and an employment growth of 0.3 percent were observed (Euratex, 2016b). Focusing on the Dutch clothing industry, there is fierce price-related competition between retailers, and decreased sales, because of recent financial and economic crises, leading to lower margins (Modint, 2016). However, sales are expected to rise again, given the recent recovery of the economy. These figures illustrate that important socio-economic interests are at stake in this production-consumption system. At the same time, the system seems to become subject to debate regarding environmental aspects. For example, in the textile industry 30 percent of costs are derived from electricity, while the energy used for yarning and spinning is mostly non-renewable at this moment (Muthu, 2014). Rising global non-renewable energy prices will cause higher costs downstream (Euratex, 2014), strengthening attempts to compensate this by reducing other costs, e.g., by implementing more industrial and automated production systems, which in turn jeopardizes local employment.

Recovery and waste industry

People and Profit: It appears difficult to find global figures for this industry. Therefore, we limit ourselves to the Dutch situation. In 2017, there are 2,225 collectors and second-hand stores within the Netherlands of which 22 percent are stores specialised in second-hand clothing (CBS, 2017). This number represents an increase of four percent in comparison to 2015 (CBS, 2015). The second-hand clothing stores employ 1,465 people, which is an increase of 0.3 percent compared to 2015 (CBS, 2017). 64.8 percent of the employees are people with what is called 'a distance to the labour market', which means that they generally have some handicaps and as a result, their entry into the labour market is restricted, making them more than average dependent upon social care (BKN, 2016). The average turnover of Dutch second hand stores (members of the second-hand association) increased by 11 percent from 90 M€ in 2014 to 100 M€ in 2015 (Kleinjan, 2017). The assumption is that this is due to economic recovery and the increasing quality of products (Kleinjan, 2017). At the same time, the Dutch clothing industry deals with a high level of obsolete inventory. For instance, in 2015, 6.5 percent of textile and clothing remains unsold, and hence remain 'stuck' in the forward supply chain. Of this category, 1.4 percent remains at the production stage, 1.1 percent at the wholesale stage, and 4.2 percent at the retail stage (Wijnia, 2016). Of this 6.5 percent, 35.2 percent is perceived as 'end-of-use' material, collected by commercial firms and exported for re-use in Eastern Europe, Asia and Africa, while another 35.6 percent is collected by charities and exported for re-use to the same destinations. 17.6 percent is kept in stock, while 5.9 percent is sold in outlet stores, 3 percent recycled, and 2.7 percent incinerated. In total, this accounts for 314 M€ turnover loss in 2015 for the Dutch retail market (Wijnia, 2016). When it comes to the reverse supply chain, 210 Kt 'end-of-use-cycle' and 'end-of life-cycle' textile and clothing are annually collected separately within the Netherlands, whereas 145 kilotons are not collected separately (Ffact, 2012). In other words, annually 80 M€ ends up in the garbage can (TAUW, 2011), in particular due to operational uncertainties, such as the timing, quantity and quality of returned clothes as well as capricious consumer behaviour (Guide et al., 2009).

Consumption (sub-)system

People: Current consumer behaviour patterns towards apparel and the use of apparel are based on social pressure to compare themselves with others through the accumulation and display of possessions, the continuous replacing of apparel with 'updated' versions, the cultural obligation to experience everything and buy things accordingly, and constant consumption as part of a continuous process of identity formation (Fletcher, 2008; Wicker, 2016). This situation does not stimulate receptiveness for information and actions stimulating sustainably use of apparel in order to maintain its quality and to reduce environmental impacts.

Planet: Research shows that 8 percent of Dutch CO_2 emissions are (in) directly caused by the use of clothes and shoes (Jansen, 2014). One could argue that this is mainly caused by the laundry practices of consumers (Dombek-Keith & Loker, 2011; Sherburne, 2009). Aggregation of this finer-scale study into global studies teaches us that the actual volume of water required to wash clothing equals to about ten percent of the global water footprint (WRAP, 2012). Furthermore, it accounts for over 850 Mt of CO_2 per year, which is equivalent to three percent of global CO_2 generation, i.e., 51 kg CO_2 per-person per year (Carbon Trust, 2011b). Various authors suggest that for frequently washed garments, the effects of reducing water and energy use during washing, drying and ironing processes are larger than the possible effects of modifying production methods (Dombek-Keith and Loker, 2011; Sherburne, 2009).

Profit: In the Netherlands, average spending on apparel per household in 2016 was five percent of spendable income, which is on average €1,700 annually (CBS, 2016a; CBS, 2016b). In the last five years, the average dropped by 1.5 percent, mainly due to the financial and economic crises (CBS, 2016a; CBS, 2016b). When it comes to consumer behaviour, within the Netherlands, there is ambiguous consumer behaviour: although consumers have a positive attitude towards environmental protection, they rarely translate this attitude into sustainable fashion consumption (Niinimaki, 2010; Chan & Wong, 2012). Consumers are interested in purchasing sustainable garments, yet they are (on average) not willing to make personal sacrifices, such as paying a higher price.

c. External developments affecting the apparel system in the medium and long term

Global resource scarcity

Global resource scarcity is increasingly affecting both the forward and the reverse apparel supply chains. Resource scarcity is further increased by (a) population growth, (b) disequilibrium between production and consumption, and (c) economic levelling of nations around the world (Bell et al., 2013). The current world population of 7.3 billion is expected to reach 8.5 billion by 2030 and 9.7 billion by 2050. Population growth will mainly take place in Africa, South and Southeast Asia, and Latin America (UN DESA, 2015). Meanwhile, the balance between production and consumption of resources is changing. In 2016 all resources (e.g., cotton, refined oil) the earth can generate on average per year were actually consumed within the first eight months (Kraaijvanger, 2016). Growth of the population in general and of the middle-class population in particular generate a (fast) growing need for apparel in emerging countries such as China, Russia and India. Karaosman (2016) expects that this will lead to an increase in competition for apparel production in the near future. By the mid-2020s, these countries will have turned into key forces shaping global apparel supply chains (OECD/FAO, 2016). Hence, without significant system changes, the growing population and middle-class in emerging countries and the associated consumption of resources like cotton and refined oil may lead in the medium and longer term to a further unbalance between production and consumption.

Climate change

The estimate is that global CO_2 emissions from cotton may reach 300 Mt in 2020, which is about 2.7 percent above the current level, if the business-as-usual scenario is pursued with no reduction in emissions (Carbon Trust, 2011a). The way the climate will change in coming years will be critical in shaping the future apparel supply chain system. This system is particularly sensitive to climate change because of its reliance on high-quality raw materials stemming from natural and agricultural systems that are geographically limited (Crowley et al., 2015). Climate-related hazards such as changes in the intensity and frequency of extreme weather events like hurricanes, droughts, floods and changes in precipitation patterns will affect the availability of water, while the vulnerability and exposure of natural systems will lead to a loss and degradation of biodiversity and ecosystem services such as water filtration, soil replenishment and crop pollination, as well as related social consequences such as loss of livelihood.

Geopolitical developments

In the past decade, geopolitical tensions have intensified, due to developments like (e.g. Quaedvlieg, 2016) (a) fast growing New Economies (e.g., China, India) and their need for access to basic resources, (b) stagnating traditional economies (e.g., Europe, USA) causing growing nationalism and protectionism, (c) increasing tensions between East and West having effect on e.g., energy supply and dependency, (d) regional conflicts causing large-scale migration of populations and intensifying cultural clashes, (e) effects of global warming causing natural disasters and (f) the easy access to new production and service technologies replacing traditional hand-based labour and causing large scale unemployment at the bottom of labour markets. The global system is rapidly changing into a multipolar system. Opinions about the likeliness of a stable and steady development of the global economy become increasingly diverse. Production systems that are based on consuming natural and production resources in different global areas, are vulnerable to these developments. They tend to cause more rapidly fluctuating prices of scarce resources, more dependency on geopolitical stability, and more hesitation with respect to the necessary investments (e.g., in more sustainable production and distribution methods). This trend increasingly conflicts with the need for more product differentiation and quality, fast responses to changing market needs, sails reliability and stable selling prices. Recently, Burberry announced to reinvest in 1000 new jobs in the UK, and Nike in 10.000 new jobs in the US. Smaller brands in the US and Europe seem to follow. These small examples of reshoring illustrate a robust trend.

Technological developments
In the coming decade, technological developments such as 3D-printing, new types of sustainable fibres such as ''Miscanthus Giganteus'', continuing automation, the Internet, smartphones and recovery technologies will (have the potential to) influence the current apparel system. The concept of mass producing apparel half way around the world and then shipping them is inherently (economically and environmentally) inefficient. Alternatively, 3D-printing technology could disrupt manufacturing and the global apparel supply chain, meaning that products are produced on demand for local delivery, and thus many transports and logistics needs will disappear. However, at the same time, it is assumed that 3D-printing technology and continuing automation will threaten 85 percent of employment in developing countries in the upcoming decade (Citi, 2016). Then, ''Miscanthus Giganteus'' is a species of grass with a highly efficient photosynthesis. This newly developed fibre is suitable for various applications, and may potentially be used to substitute raw materials (e.g., cotton) in the textile industry (Knowles, 2015). In addition, global access to internet via smartphones and the growth in e-commerce and social media has ensured that everyone can see how everyone lives. As a result, worldwide expectations and international competition keep on growing, and the lead-time of, in particular, fashion apparel keeps on decreasing. This allows overconsumption and low-pricing policies, resulting in an increasing amount of waste and low-quality end-of-life fabrics (Pookulangara & Shephard, 2013).

Furthermore, apparel recycling while maintaining quality is still very difficult. For instance, the decline in quality of apparel and the 'chopping-up' process tend to further lower the cotton's quality. The 'chopping-up' process shortens the staple length of fibres, while the staple length influences the strength and softness of cotton threads. At the same time, recycling technologies of textiles and clothing are still lagging behind, although they could lead to major environmental gains. For instance, Zamani (2014) states that when applying an integrated textile recycling system, 10 tons CO_2-eq and 169 GJ could be saved per ton of textile waste. However, the number strongly depends on the yield of the processes in such an integrated system. It implies combining different technologies (e.g., mechanical recycling, chemical recycling) for the treatment of one ton of textile waste.

d. Value adding concepts and regulatory measures for a circular clothing system

Based on the current situation of the apparel system, which is still primarily based on extensive resource use, i.e., a 'take-make-dispose system' with often single feedback loops in terms of 're-use' and 'recycling', as well as the external developments affecting the production system of the apparel industry in the future, it is important to integrate value adding concepts with the aim of maximizing value creation over the entire lifecycle of apparel with dynamic recovery of value from different types of return over time (Guide & Van Wassenhove, 2009). Value adding concepts from the forward and reverse supply chain system that may leverage value creation can be classified into 'product design characteristics', product-service concepts', 'integrated supply chain processes', 'partnerships and collaboration', 'organizational characteristics' and 'IT solutions' (Koppius et al., 2014; Schenkel et al., 2015).

Product design characteristics

There are various design measures needed to increase circular system performance in terms of economic and environmental value. These are contained in a variety of design principles such as 'design for re-use' (Atasu et al., 2010), 'design for disassembly' (Kumar & Putnam, 2008), 'design for recycling' (Kriwet et al., 1995), 'eco design' (Laosirihongthong et al., 2013), et cetera. For instance, various firms within the textile industry are searching for ways to switch towards recycled cotton to reduce the sourcing of primary cotton. Herewith up to 20,000 litres of water per kilo of cotton can be saved (Luz, 2007), which contributes to lowering the impact of the estimated 40 percent shortfall in water supply by 2030. In addition, research in carbon, water and waste impacts of UK clothing shows that switching of cotton fabric into 50:50 poly-cotton-blend fabric could also reduce the water footprint by three percent, the waste footprint by 1.7 percent and CO_2 emissions by 0.4 percent (Idle, 2017). In addition, product design concepts, such as modularity of design for disassembly, increase the re-use rate of materials by simplifying low-level separation of valuable components, thereby creating economic and environmental value.

Product-service concepts

In response to more difficult access to resources and climate change, it is important to increasingly retain ownership of apparel and, where possible, act as service provider, hence, selling the use of products, not their one-way consumption. This shift has direct implications for the development of efficient and effective tack back systems and the proliferation of product- and business model design practices that generate more durable apparel, facilitate disassembly and refurbishment and, where appropriate, consider product/service shifts. This shift also leads to resource efficiency and would reduce carbon, water and waste footprints. For instance, when the life time of clothing can be extended by nine months via a product-service concept, carbon, water and waste footprints would already be reduced by up to 30 percent each and resource costs would be reduced by about 20 percent (WRAP, 2012). Note that these are figures from the British context. However, important to notice is that for consumers, having control over products such as clothes is one of the most valued attributes: ''Product-service concepts are often less accessible, or have less intangible value, than the competing product, in part because product-service concepts usually do not allow consumers as much behavioural freedom or even leave them with the impression that the product-service provider could prescribe how they should behave'' (Tukker, 2015: 76).

Integrated supply chain processes

In a circular system, the forward and reverse supply chains are integrated, constituting a system with three to integrate sub-processes to either maximize profitability or minimize costs (Guide & Van Wassenhove, 2009). It concerns (a) the Front-End process, (b) the Engine process, and (c) the Back-End process. The Front-End process is based on the activities 'product acquisition' and 'reverse logistics' of clothing. Product acquisition can be described as the acquisition of used (discarded) products that serve as the input to a reuse system (Guide & Van Wassenhove, 2002). Issues concerning product acquisition are the design of facilities for collecting 'end-of-use' or 'end-of-life' apparel (centralized or decentralized), planning product management, and policies to control inventory (De Brito et al., 2005; Guide & Van Wassenhove, 2002). The success of product acquisition is strongly influenced by the uncertain timing, quality and quantity of returns, as well as the reusability and demand for recovered products (Atasu et al., 2008; Koppius et al., 2014). Reverse logistics involves the transportation, storage and transhipment of clothing. Transportation refers to obtaining the product returns and transports to the location where the related Engine activities will take place. Storage and transhipment of product returns are often additional activities to prevent high inventory costs for manufacturers (Guide & Van Wassenhove, 2002).

The Engine sub-process is based on the operational activities for valuing (i.e. taxation) and recovery of apparel. Taxation concerns the first inspection and sorting of products returns. In some cases, taxation requires high asset investments (Toffel, 2004). For instance, a specialized machine is designed only to recognize and sort particular colours, where the machine's value would depreciate if applied to any other selection criteria, e.g. on material level such as cotton, bio-cotton, polyester. In the current apparel system, the most common option of product recovery is direct re-use, while parts harvesting, recycling, refurbishment (i.e., repair) and remanufacturing are marginally used. Although 'recycling' is becoming more and more topical, many apparel today consists of mixed materials, which makes it more difficult to recycle. The Back-End sub-process involves the remarketing of recovered products/materials in terms of market selection and sales (Atasu et al., 2008; Guide & Van Wassenhove, 2009). There are a number of sales channels available for recovered apparel. For instance, regarding recycled apparel, a manufacturer may choose to use the same channel that is being utilized for apparel not made of recycled fibres. Or in the case of refurbished apparel the manufacturer can create two different markets, i.e. the original market for new products and another market for the refurbished apparel (Prahinski & Kocabasoglu, 2006), also to minimize eventual market cannibalization effects (Atasu et al., 2010).

Partnerships and collaboration

Partnerships and collaboration facilitate the re-integration of recovered apparel and materials into the original forward supply chain. There are various forms of partnerships and collaboration; traditionally a distinction is made between vertical and horizontal coordination. The majority of research agree that vertical coordination is beneficial to forward and reverse supply chain management (e.g., Aitken & Harrison, 2013), yet few studies specifically analyse the advantages of horizontal or other forms of collaboration such as inter-firm networks (Mihi Ramírez, 2012), or third-party service providers (Sheu & Gao, 2014).

IT solutions

IT solutions, such as real-time information coordination (Lee & Lam, 2012), are very often already implemented in the forward supply chain in order to improve customer service levels or reduce inventory. IT solutions such as 'radio frequency identification' (RFID) add value by enabling information collection in the integrated forward and reverse supply chain (e.g., Lambert et al., 2011; Huscroft et al., 2013). For instance, in the Netherlands a circular content management system is built, which enables customers to gain information about the materials that have been used for the production of their clothes, about who manufactured the clothes, and about the environmental impact of the production (Mentink & Houben, 2014). Furthermore, ''smart clothing'' which enables digital components and electronics to be embedded in them, can be socially and ecologically beneficial. For instance, the integration of electronic sensing skin into clothes presents structural health monitoring benefits of ageing infrastructure in improving public safety (Chen et al., 2016).

Organizational or governance characteristics

The five above mentioned concepts or approaches (product design, product-service, supply chain processes, partnerships and collaboration, IT solutions) are interrelated (Schenkel et al., 2015), constituting a complex system that differs significantly in structure and operations from the traditional linearly organized apparel industry. The transformation process towards the development and management of value adding circular clothing systems is assumed to benefit from innovative leadership approaches (Defee et al., 2009), responsibility sharing (Jacobs & Subramanian, 2012), cross-functional integration and organizational alignment (Mollenkopf et al., 2011). For instance, Defee et al. (2009), argue that a circular system orientation is facilitated when the supply chain leader performs a transformational leadership style, a style that aims to raise the consciousness of stakeholders regarding possibilities in the future by encouraging them to rise above their own interests for the purpose of the network, and focus on strategic development rather than merely focusing on immediate needs (Bass & Avolio, 1994).

Legislation

Legislation can either promote or limit innovation towards a circular apparel system. From a Dutch perspective, the government has indicated the desire to eliminate restrictive legislation on the one hand, and to develop legal frameworks on the other hand, that stimulate innovation, enforce dynamics and support investments for a circular economy. Therefore, the government is planning to, among others, (a) stimulate circular business models, (b) provide space in regulations for experimentation, (c) expanding producer responsibility, (d) stimulate circular product design, et cetera (Ministry of Infrastructure and Environment and Ministry of Economics, 2016). One of the Dutch legal frameworks for stimulating and supporting the circular economy for clothing and textile is the 'National Waste Management Plan 3' (LAP). In this plan, textile is one of the seven priority material flows and had a guiding objective to achieve a 20 percent reduction in environmental impact over the entire supply chain by 2015. However, unfortunately this objective has not been achieved. In response, the new LAP (i.e., LAP3) intends to pay more attention to how to achieve this objective. This is in particular relevant since reality seems to move in the opposite direction. The general objective of 75 percent waste separation in 2020, enables municipalities to compensate textile collection with other priority waste fractions such as plastics, metals, wood, construction waste, paper & cardboard and electronics. At first sight, one might argue that is not a problem, yet like mentioned earlier, within the Netherlands, six percent of our CO_2 emissions is caused by clothing. Hence, the separate collection of 'end-of-use' and 'end-of-life' clothing and textile should be properly stimulated and not become subject of a trade-off with other waste categories. Other regulatory measures that could be implemented in response to global resource scarcity are for instance ensuring that domestic markets are supplied first (Reuters, 2008)), or ensuring exclusivity of supply (see more, Reuters, 2009). The analysis of the potential for value added approaches in the apparel industry is summarized in Figure 3.

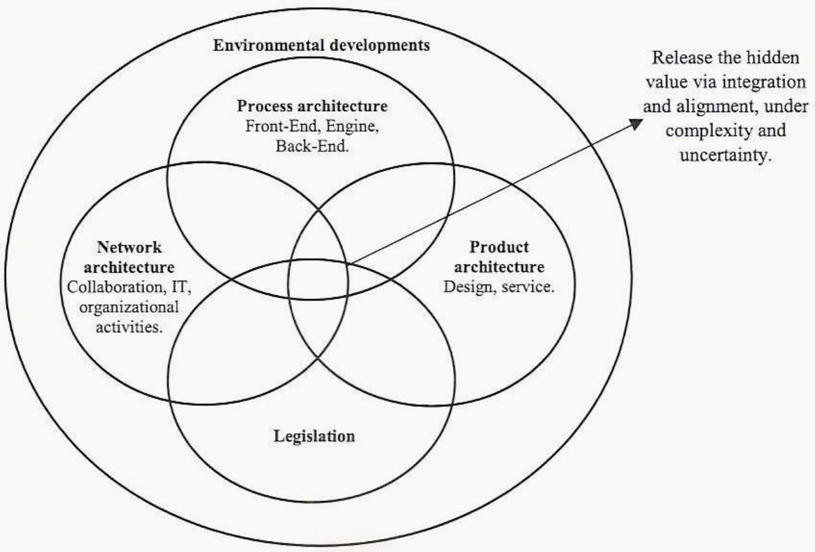

Figure 3. Value adding characteristics for circular value chain system management

5. Conclusion and discussion

The analysis in this chapter was triggered by an increasing sense of urgency for transitioning from linearly organized economic systems towards circularly organized economic systems. Therefore, the basic notions underlying circularity are described and the potential benefits are explored from a sustainability perspective. Furthermore, the complexity of the transition process has been elaborated and illustrated with the case of the apparel industry.

Based on these analyses, it becomes clear that indeed the linear economy is reaching its limits, or in the case of the clothing industry in certain aspects has already passed the limits. The concept of circularity has clear theoretical, economic, social and environmental benefits. However, an appealing concept alone is not sufficient to bring about large-scale changes. Supported by the analysis of the clothing industry practice, it must be recognized that transformation towards a circular economy is a normatively justifiable as well as practically messy challenge: the discrepancy between the actual and the desired state of the system is enormous.

Public and private decision makers, taking up this challenge and trying to influence the structure and performance of the system, must learn to cope with serious uncertainties due to the complexity of the system and its dynamics: they decide on events and situations where impact and probability of occurrence of various effects are both unknown (Marchau, 2014). Marchau summarizes these in terms of (a) uncertainties related to different demographic, socio-economic, geopolitical and technological scenarios, (b) uncertainties about the non-linear interactions and feedback effects between key elements within the system, occurring time delays as well as accelerations, determining the partly unpredictable behaviour of stakeholders and the impacts of interventions, and (c) uncertainties about the valuation of outcomes by different stakeholders. These types of uncertainty are very recognizable with regard to the presented exploration of the apparel industry. Marchau adds to this classification of uncertainties so called 'deep uncertainties', occurring when analysts and decision makers do not know or do not agree upon what model and probability distributions should be used to describe the system or how to evaluate the desirability of alternative outcomes (see also Kwakkel et al., 2016). With respect to interventions for circularity, such evaluations largely depend upon the weights attached to the triple bottom line (economic, social, environmental) impacts of alternative circular supply chain activities.

So far, limited multi-disciplinary, system-encompassing, research has been conducted in this domain, and consequently our awareness and knowledge are limited on what combinations of actions should be implemented, and when, to optimize the multiple value creation process. The illustrative analysis of the situation and developments in the clothing industry showed however, that serious options exist for sustainable improvements. Moreover, the sense of urgency for change is arguably high. Multiple value creation, i.e., value creation in multiple domains, by implementing more circularity-enhancing measures and concepts is within reach when all stakeholders take their responsibility and work together for a successful integration and alignment of transition initiatives in the industry.

It was mentioned that knowledge-related factors, among other things, can impede this collaboration. Dissemination of new knowledge is often hindered by the separation between (scientific) research and (hands-on) practice into two different worlds, with little interaction and cross-fertilization. Dissemination of newly generated knowledge consequently often remains limited to the world of scientific researchers. In the Netherlands, this problem has been recognized and has stimulated various initiatives to bridge these two worlds, such as creating knowledge networks regarding the circular economy, subsidies from the National Science Foundation for initiating collaboration between companies in research aimed at circular innovation and business models, and the organization of local 'living labs' for circular initiatives.

For academic researchers, such as the authors of this paper, these collaborations provide opportunities to intensify the study of the apparel or any other industry, dynamic, non-linear and re-enforcing interactions within these industries, to explore the possibilities and potential impact of circularity-based interventions. Participative intervention methods, such as serious gaming and participative group model building (see e.g., Vennix, 1996; Sterman, 2000; Rouwette, 2003), in combination with organizing small scale transition processes may provide an interesting approach for stimulating and facilitating real-world changes considering complexity and deep uncertainty.

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